Plastic Surgery and Smoking: A Prospective Analysis of Incidence, Compliance, and Complications

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Background: Tobacco use remains a persistent risk factor in elective plastic surgery. Although nicotine is thought to increase complications, which procedures are affected and the reliability of patient-provided histories remain poorly defined. The authors sought to examine nicotine use and its impact on outcomes.

Methods: All patients in a single-surgeon practice undergoing surgery with general anesthesia during a 2-year period were enrolled. Preoperative evaluation included a thorough smoking history. All patients had urine samples taken on the day of surgery to assess for nicotine metabolites. Patients were followed for a minimum of 3 months after surgery and monitored for complications.

Results: Four hundred fifteen patients were enrolled. Of these, 139 (33.5 percent) stated that they had quit smoking and 39 (9.4 percent) were admitted active smokers. For the 362 patients with urine nicotine analysis available, 54 showed active smoking. Fifteen of these (4.1 percent) had denied current tobacco use. Patients stating that they had quit smoking were more likely to be deceitful than those stating they had never smoked ($p < 0.001$). Smokers had significantly higher overall complication rates (OR, 3.7; $p < 0.001$) and tissue necrosis rates (OR, 4.3; $p = 0.02$) and were likelier to require reoperation (OR, 3.7; $p < 0.001$).

Conclusions: In a large cohort study examining the prevalence and impact of nicotine in the general plastic surgery population, substantial rates of deception regarding smoking status were found. Furthermore, active smoking was strongly correlated with complications. A methodologic approach to the detection and management of patients using tobacco products can help to optimize outcomes. (*Plast. Reconstr. Surg.* 131: 385, 2013.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Risk, II.

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RISK

Tobacco use is the most significant modifiable cause of death and disease in the developed world today.[1,2] Cigarette smoke is known to contain approximately 4000 chemical substances, including chemical toxins and carcinogens such as hydrogen cyanide, carbon monoxide, and benzene.[3] The link between tobacco use and wound healing complications following plastic surgery is well known. Deception is also known to exist among smokers.[4–6] Given the prevailing attitudes toward smoking, many smokers may feel compelled to misrepresent their current status.

It is common anecdotal experience among surgeons that patients do not fully appreciate the risks associated with these products or simply choose to believe complications will not occur with their procedure. There are now a number of methods to assess and measure nicotine and its metabolites using simple, accurate, and relatively inexpensive body fluid tests. This gives the surgeon the ability to determine preoperatively whether the patient is smoking and to enforce changes when necessary. Data on the prevalence

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Received for publication May 1, 2012; accepted August 10, 2012.
Presented at the 2011 Annual Meeting of the American Society of Plastic Surgeons, Denver, Colorado, September 23 through 27, 2011.

DOI: 10.1097/PRS.0b013e318277886a

Disclosure: *The authors have no financial disclosures relating to the content of this article.*

of smoking and its impact on outcomes in the general plastic surgery practice are essential in enabling surgeons to develop a personalized approach to the detection and management of smokers. The purpose of this study was therefore to assess smoking habits in the plastic surgery patient population, to correlate urine levels of nicotine metabolites with self-reported smoking status, and to determine whether the presence of nicotine metabolites had predictive value for complications.

PATIENTS AND METHODS

All patients in a single-surgeon practice (S.C.B.) at the Central Maine Medical Center undergoing surgery under general anesthesia over 2 years were included in this study. Preoperative evaluation included a thorough smoking history. All patients were counseled on the risks of smoking, tobacco product use, and secondhand exposure whether or not a history of tobacco use was stated. Patients presenting for elective surgery involving flaps, extensive skin undermining, or any unusually complex procedure were required to discontinue smoking before scheduling surgery. Such procedures included breast reduction, abdominoplasty, free tissue transfer, and the repair of recurrent hernias. Any patients undergoing surgery while known to be actively smoking were therefore undergoing procedures considered "lower risk." Patients required to discontinue smoking because of the complexity of their surgery had to provide a negative nicotine test before scheduling surgery. This was typically obtained at the final preoperative visit several weeks before the date of surgery.

This approach represented the existing routine in our practice developed over a period of years. All patients, regardless of history or procedure, then had a urine sample taken on the day of surgery to assess actual nicotine status. Results were not available at the time of surgery. Therefore, some patients who had previously been required to provide a negative nicotine test had positive test results for the purposes of this study because they resumed smoking. Urine samples were processed and analyzed for tobacco metabolites by ARUP Laboratories (Salt Lake City, Utah). The laboratory charge to the hospital for this test was $68. Patients were followed for a minimum of 3 months after surgery and monitored for complications, including poor wound healing, infection, partial and complete flap loss, fat necrosis, and reoperation.

Statistical analysis was performed with Stata/SE version 10.0 (StataCorp LP, College Station, Texas). The t test and Mann-Whitney U test were used for two-group comparison of normally and nonnormally distributed variables, respectively. Univariate logistic regression was used to examine the predictive value of individual variables for complications with multivariate regression to control for relevant covariates. Only the first operation for any patient was included in the statistical analysis for this study. Gender information was removed as part of the deidentification process and was unavailable. Institutional review board approval was obtained from the Institutional Review Committee for the Central Maine Medical Center (Lewiston, Me.).

RESULTS

Over a 2-year period, a total of 415 patients were enrolled in this study. Table 1 illustrates the most common procedures, and Table 2 shows the breakdown by general category.

Characteristics of Smokers

Among the 415 patients in the study, 139 (33.5 percent) stated that they had quit smoking before their initial consultation, whereas 39 (9.4 percent) were admitted active smokers (Table 3). Active smokers were no older than nonsmokers (43.1 versus 40.0 years, $p = 0.26$), nor did they have higher rates of comorbidities, including coronary artery disease, diabetes, hypertension, renal disease, or pulmonary problems ($p > 0.1$ for all) (Table 4). The mean smoking history was comparable between active smokers and those who had quit (14.3 pack-years versus 18.4 pack-years, respectively; $p = 0.3$).

Table 5 shows the distribution of nicotine status among the 362 patients with urine nicotine results from the day of surgery. Three patients stated that they were active smokers but showed no recent exposure to nicotine. Among the 54 patients who showed active nicotine exposure, 15 (4.1 percent) had denied current tobacco use

Table 1. Distribution of Common Procedures

Type of Procedure	No. of Procedures Performed (%)*
Reduction mammaplasty	70 (16.9)
Breast augmentation	62 (14.9)
Abdominoplasty	17 (4.1)
Free TRAM flap	16 (3.9)
Nipple reconstruction	11 (2.7)
Breast augmentation and mastopexy	11 (2.7)
Pedicled TRAM flap	10 (2.4)
Benign excision	10 (2.4)
Revision of scar	7 (1.7)

TRAM, transverse rectus abdominis myocutaneous.
*Percentage of total number of procedures performed ($n = 415$).

Table 2. Distribution of Procedures by Category

Procedure Category	No. of Procedures Performed per Category (%)*
Breast	209 (50.4)
Minor skin procedure	95 (22.9)
Body contouring	40 (9.6)
Pedicled flap	26 (6.3)
Trauma	21 (5.1)
Free tissue transfer	20 (4.8)
Other	18 (4.3)

*Percentage of total number of procedures performed ($n = 415$).

Table 3. Smoking Status from Patient History

Smoking Status	No. (%)*
Never	237 (57.1)
Quit	139 (33.5)
Active	39 (9.4)

*Percentage of total number of procedures performed ($n = 415$).

(Fig. 1). Although neither age nor pack-year history predicted deceit about recent nicotine use, patients who stated that they had quit smoking were more likely to be deceitful than those who stated they had never smoked, with active nicotine metabolites in 9.8 percent of "former" smokers versus 1.5 percent of "never" smokers ($p < 0.001$). In addition, patients who claimed to have quit smoking within the past 6 months had a 21.7 percent rate of deceit as compared with 5.4 percent in those who claimed to have quit greater than 6 months ago ($p = 0.026$).

A strategy of preoperatively testing only patients who claimed to have quit smoking within the past 6 months would have led to a 97.2 percent tobacco-free cohort, whereas checking all patients with a history of smoking resulted in detection in 99.2 percent. In the self-reported nonsmoker population, one deceitful smoker would be discovered for approximately 66 negative tests, at a cost per detected smoker of $4488. In comparison, this rate was one in 10 in the "former" smoker cohort and one in five for patients who claimed they had quit in the past 6 months, costing $680 and $340, respectively.

Smoking and Outcomes

Table 6 shows the distribution of complications overall and by smoking status. There were no significant differences in distribution of procedures by category ($p > 0.1$ for all) in the nonsmoking cohort. Despite this, these patients had significantly higher overall complication rates (OR, 3.7; 95 percent CI, 1.7 to 7.8; $p < 0.001$) and tissue necrosis rates (OR, 4.3; 95 percent CI, 1.2 to 15.4; $p = 0.02$) and were likelier to require reoperation (OR, 3.7; 95 percent CI, 1.4 to 9.6; $p < 0.001$). Differences in infection, bleeding, and dehiscence rates did not reach significance. Table 7 illustrates individual complication rates by smoking status for the two most common categories (breast and minor skin operations).

Among the 15 patients who had active tobacco metabolites despite denying smoking, there were again no differences by procedural category ($p > 0.1$). Although differences in overall complication rates for these patients did not reach significance (OR, 2.5; 95 percent CI, 0.7 to 39.1; $p = 0.18$), there was a higher rate of wound infection (OR, 6.7; 95 percent CI, 1.3 to 34.1; $p = 0.02$). Interestingly, this effect appeared to be primarily applicable to active smokers; exclusion of patients who had detectable metabolites but greater than 2 weeks since tobacco use led to stronger trends toward complications (OR, 3.9; 95 percent CI, 1.0 to 15.7 percent; $p = 0.06$), infection (OR, 10.75; 95 percent CI, 2.0 to 58.9; $p = 0.006$), and reoperation (OR, 4.4; 95 percent CI, 0.9 to 22.1; $p = 0.07$).

DISCUSSION

The purpose of this study was to assess the impact of tobacco use on outcomes following plastic surgery. The risks associated with smoking in the surgical patient are numerous and include pneumonia, cardiac arrhythmias, variability in response to drugs while under anesthesia, thrombosis, poor or delayed wound healing, wound dehiscence, wound infections, and scarring. Deleterious effects on wound healing have been studied extensively in animal models and have long been known within the specialty of plastic surgery.[7–10] In one of the first publications addressing the relationship between smoking and complications in plastic surgery, Rees et al. reported that smokers undergoing face lifts were more likely to suffer from skin slough.[11] A later study by Riefkohl et al. also demonstrated that current and former cigarette smokers had greater histologic microvascular occlusive disease and increased likelihood of skin slough after face lift.[12]

A number of studies have linked tobacco use with complications following breast reconstruction. In a large retrospective review, Chang et al. found increased risk of mastectomy flap and abdominal wall necrosis following free transverse rectus abdominis myocutaneous (TRAM) flap reconstruction.[13] The risk was most pronounced

Table 4. Patient Demographics by Smoking Status

	All Patients	All Smokers*	Nonsmokers	*p*†
No. of patients	415	51	364	
Mean ± SD age, yr	42.8 ± 16.4	41.1 ± 12.9	43.1 ± 16. 9	0.42
Pulmonary disease	1.9%	4.0%	1.6%	0.26
Coronary artery disease	2.4%	0%	2.7%	0.24
Diabetes	1.9%	0%	2.2%	0.29
Hypertension	9.2%	4.0%	9.9%	0.18
Renal insufficiency	4.8%	0%	0.5%	0.60

*Active smoking by history or nicotine test.
†Derived from *t* test (continuous variables) or χ^2 test (categorical values) for difference between groups.

Table 5. Nicotine Status from Urine Nicotine Analysis

Nicotine Status	No. (%)
No exposure	305 (84.3)
Passive exposure	3 (0.8)
>2 Weeks since smoking	10 (2.8)
<2 Weeks since smoking	44 (12.2)
Total	363

for patients who had at least a 10-pack-year smoking history and least when patients quit smoking at least 4 weeks before surgery. In a retrospective review of 624 free flap breast reconstructions, Seidenstuecker et al. found significantly higher rates of delayed donor-site wound healing in smokers.[14] Herold et al. found that smoking did not significantly impair the outcome of free flap transfer but was correlated with wound breakdown in a review of 150 patients.[15] There have also been studies linking smoking with skin flap necrosis and other wound complications following pedicled TRAM flap surgery.[16–19] In a review by Hartrampf and Bennett, all patients who underwent TRAM flap surgery and subsequently had donor-site skin necrosis were smokers.[17] Implant-based breast reconstruction has also been shown to be negatively affected by smoking, with greater rates of mastectomy flap necrosis, infection, and loss of implant.[20,21] In a retrospective review of reduction mammaplasty cases, Chan et al. noted a significant increase in wound healing problems following reduction mammaplasty and suggested the compulsory use of nicotine testing.[22]

Smoking has also been linked to poor outcomes in general reconstructive procedures. Finan et al. found that smoking significantly increased wound infection rates following ventral hernia repair and considered this to be the only modifiable risk factor.[23] In a review of 1881 patients, smoking was found to correlate with decreased skin graft survival.[24]

Although previous studies have correlated tobacco use with plastic surgical complications, the vast majority have relied on patient self-reporting. However, smokers are known to frequently misrepresent their status in a doctor's office, and self-reported data have been shown to be unreliable.[22,25] A study by Marin et al.[26] used serum cotinine levels as an objective measure to assess the effects of tobacco on wound complications in head and neck reconstruction. They found that preoperative cotinine levels were more predictive of wound healing complications than self-reported smoking status. Given the inextricably linked nature of head and neck cancer with chronic tobacco abuse, however, these results cannot be easily generalized to the general plastic surgery population. In a study of 50 patients undergoing breast reduction, half self-reported smokers and half nonsmokers, Bartsch et al. measured urine cotinine levels preoperatively and on the fourth postoperative day. Although they did not examine deception, they found that smokers who developed impaired wound healing did have higher levels of cotinine compared with smokers with no complications.[27]

We performed preoperative nicotine testing using a large cohort encompassing a broad spectrum of plastic surgery procedures. Our data support the hypothesis that tobacco use predisposes patients to postoperative complications. Although this finding is not surprising, it is interesting to note that tobacco users were more likely to suffer from complications despite the fact that self-reported tobacco users were precluded from receiving "high-risk" procedures involving flaps, extensive undermining, or complex reoperations. Many plastic surgeons will offer known smokers a subset of elective procedures that they deem to be justifiable based on the assumption that they are safe in the smoking population. In a large survey by Rohrich et al. in 2002, 90 percent of respondents offered elective procedures to known smokers, but the majority refused to offer skin flaps or extensive undermining.[28] Our data suggest that the belief that careful surgical selection will mitigate the deleterious effects of tobacco use may be wishful thinking.

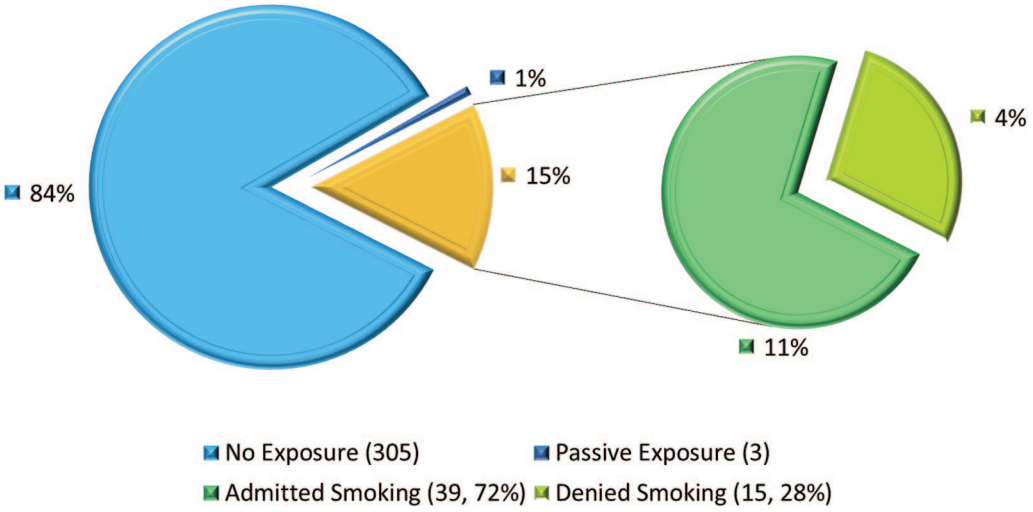

Fig. 1. The frequency of smoking based on urine nicotine analysis including subgroup breakdown of the 54 patients (15 percent) with detected nicotine use.

Table 6. Complications ($n = 415$)

	Nonsmokers ($n = 364$)	All Smokers* ($n = 51$)	Deceitful Patients ($n = 15$)
Any complication, %	7.7	23.5†	20.0
Infection, %	2.2	5.9	13.3‡
Tissue necrosis, %	1.9	7.8‡	6.7
Hematoma, %	1.6	3.9	0
Dehiscence, %	1.6	3.9	0
Reoperation, %	4.1	13.7†	13.3

*Active smoking by history or nicotine test.
†$p < 0.01$ for difference between nonsmokers and all smokers or deceitful patients.
‡$p < 0.05$ for difference between nonsmokers and all smokers or deceitful patients.

Our data also highlight the importance of taking deception into account when screening patients for tobacco use. Deception regarding tobacco use is a well-documented phenomenon in the smoker population.[26,29–31] This complicates use of the smoking history to avoid operating on patients with higher complication risks. One possible solution is to use preoperative testing, such as collecting urine for measurement of nicotine metabolites. Nicotine has a short half-life of 2 hours before being metabolized in the liver to a number of substances including nornicotine, cotinine, and 3-hydroxycotinine.[32] Cotinine has a half-life of 16 hours in the blood and can be detected for days after use in many body fluids, such as serum, urine, tears, and saliva by means of readily available testing.[33,34] Measuring metabolite levels in urine is highly sensitive and specific for recent tobacco use.[35]

Although preoperative nicotine metabolite testing is an effective method of avoiding operating on tobacco users and thus minimizing tobacco-associated complications, there are practical, economic, and ethical issues to consider. One question that arises is whether every surgical candidate who denies current tobacco use should undergo confirmatory testing as was done in our study. Although this approach would allow preoperative identification of every tobacco user seeking surgery, it is not clear that this would be the most efficient approach. One of the more interesting findings from our study is that patients who stated that they had quit smoking were more likely to be deceitful than those who stated they had never smoked. Our analysis suggests that testing only patients who claim to have quit smoking would be almost as effective in identifying deceitful tobacco users as testing all who deny current use and would save substantial cost and effort. The drawback to such a selective screening protocol is that it would require ignorance on the part of the patient, as knowledge of such a policy would encourage deceitful tobacco users to endorse having never smoked.

Another important consideration is how motivated plastic surgeons are to effectively screen all tobacco users from their practices. Tobacco use is difficult to treat.[36] Once a potential surgical candidate is identified as a tobacco user, cessation counseling is indicated, and follow-up appointments are often required to monitor progress in tobacco cessation before surgery. Surgeons recognize, however, that despite their best efforts, most tobacco users will continue to smoke. Despite ag-

Table 7. Complication Rates by Procedural Category

	Breast Procedures		Minor Skin Procedures	
	Nonsmokers (n = 183)	All Smokers* (n = 26)	Nonsmokers (n = 83)	All Smokers* (n = 12)
Any complication, %	3.8	7.7	12.1	25.0
Infection, %	2.2	3.8	3.6	8.3
Tissue necrosis, %	0.0	0.0	3.6	8.3
Hematoma, %	1.0	3.9	0.0	0.0
Dehiscence, %	0.1	0.0	6.0	8.3
Reoperation, %	2.2	7.7	4.8	0.0

*Active smoking by history or nicotine test.

gressive use of testing, we had several patients undergoing higher risk procedures provide negative nicotine tests before surgery but subsequently test positive for smoking on the day of surgery. In the setting of preoperative nicotine screening, deceitful patients found to be smoking may be even less amenable to cessation than those that are forthright about their use.

Surgeons are faced with the dilemma of whether to exclude confirmed tobacco users from their practices or proceed with elective cases knowing of the increased risk of complications. Although even supposedly "smoking-friendly" procedures limiting the use of undermining or flaps still appear to carry increased risk, it is reasonable to observe that these complications are generally local wound problems rather than major adverse events. Deciding whether to operate on a smoker remains a delicate balance between the necessity of a given procedure and the willingness of surgeon and patient to accept an increased chance of an imperfect outcome. Weighing the risk-to-benefit ratio is intrinsically subjective and must be performed on a case-by-case basis; however, it is always best for the surgeon to have as much objective data as possible to guide their decisions. The worst outcome is for a surgeon to operate on an active smoker unknowingly.

CONCLUSIONS

In a large cohort study examining smoking and nicotine metabolites in the general plastic surgery population, substantial rates of discordance between patient-reported smoking status and nicotine testing were found. Furthermore, active smoking was strongly correlated with complications and the need for further surgery. The findings of this study suggest that implementing nicotine testing among patients who endorse a prior history of tobacco use may efficiently identify deceitful tobacco users and thereby allow for well-informed decision making between surgeon and patient. A methodologic approach to the detection and management of patients using tobacco products can help to decrease complications.

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